NEW JERSEY

LIBRARY

Agricultural College Reports,

AND

ANNUAL LECTURE,

1869.

TRENTON, N. J.:
PRINTED AT THE TRUE AMERICAN OFFICE.
1870.

NEW JERSEY

Agricultural College Reports,

AND

ANNUAL LECTURE,

1869.

TRENTON, N. J.:
PRINTED AT THE TRUE AMERICAN OFFICE.
1870.

BOARD OF VISITORS.

JAMES M. MECUM,	First District.
JONATHAN INGHAM,	" "
WILLIAM HENRY HENDRICKSON.	Second District.
WILLIAM PARRY,	" "
D. KERR FREEMAN,	Third District.
JAMES BISHOP,	" "
E. BOUDINOT COLT,	Fourth District.
H. C. KELSEY,	" "
FRANCIS D. HAWES,	Fifth District.
SETH BOYDEN,	" "

REPORT OF BOARD OF VISITORS.

To His Excellency Theodore F. Randolph, Governor:

The Board of Visitors of the New Jersey State College for Agriculture and the Mechanic Arts, beg leave herewith to transmit the annual report required by law to be made by them.

The Board visited the Institution at New Brunswick, June 17th, 1869, and again December 21st, 1869. At both of these visits every facility was afforded by the Trustees of Rutgers College, and by the Faculty to enable the Board to become acquainted with the condition of the Institution under their inspection. They heard the classes of the College examined by their Professors in their various branches of study. At the summer meeting they visited the Experimental Farm, which is under the charge of George H. Cook, LL. D., the Professor of Agriculture. They heard the theses of the graduating class read, and selected from them the *best* and *second best* as the recipients of the Theses prizes, offered by the College authorities. After due deliberation the Board adopted the following resolutions, embodying their sentiments, and they are herewith reported as a part of their transactions.

Resolved, That the theses of the graduating class have been heard with great satisfaction. They show a just discrimination in the selection of their material, and a skill in its presentation which entitles them to the hearty commendation of the Board. In awarding the prizes, they consider that those containing original investigations should be ranked highest, and they, therefore, award the first prize to Edward Sealy, of Madison, and the second to Simeon E. Bucknall, of New Brunswick.

Resolved, That the Board desire to express their high gratification at the masterly manner in which the class in surveying have combined their theoretical studies with the practical operations of the field. Their descriptions of field work, and exhibition of it in their detailed drawings and maps, are entitled to special notice.

Resolved, That in the management of the experimental farm, the Trustees of the College are doing an important service to New Jersey agriculture. We consider the experiments on fertilizers which are

carried on, the interesting results of which we saw, to be especially valuable.

Resolved, That the entire examinations were highly satisfactory, both for themselves and for the promise they give of the future influence and usefulness of the course of instruction which is being carried out.

Resolved, That the institution has our entire confidence, and we desire to give publicity to our opinion, that we have in New Jersey an institution for giving instruction in sound, practical learning which is of the highest character, and deserves the support of all who are interested in industrial progress.

Resolved, That these resolutions be printed and sent to the County Superintendents, with the request that they see to it that the privileges their counties have in the College are used to their utmost extent.

The Board of Trustees of the College have used their utmost diligence to disseminate information concerning the College in the several counties of the State by means of the distribution of circulars among the County Superintendents and others interested in education. Sixteen State Scholarships are now filled, representing the following counties:—Cumberland, Essex, Mercer, Middlesex, Monmouth and Morris. It is exceedingly desirable that the counties not represented should be, and to this end the Board urge upon the County Superintendents, and all interested, to encourage promising young men to avail themselves of the opportunity for obtaining a thorough practical education. The conditions for admission are only such as may readily be acquired at the district schools of the State, and the teachers of these schools are requested to make the preparation for this institution an aim in educating the young men.

The Board of Visitors, at their autumn meeting, received from the Board of Trustees, a note asking their concurrence in a resolution so amending the conditions of admission as to require the student to be examined in the history of the United States. The Board, after an attentive consideration, gave their concurrence. From September, 1870, therefore, applicants, in addition to the previous requirements, will be examined in that subject. The importance of this subject to young men of education and influence, and the readiness with which this additional condition can be complied with will, it is felt, justify the action of the Board.

The Professor of Agriculture, Dr. George H. Cook, has, during the past term, been engaged in delivering the lecture on agriculture required by law, in the several counties of the State. These lectures have been instrumental in awakening a great deal of interest in the subject of agriculture in the communities where they have been heard, and agricultural societies and farmers' clubs have been greatly encouraged and aided in their work by them. This lecture, which the Board deem of great value and interest to the agriculturists of the

State, is herewith transmitted, and its publication earnestly recommended.

The Board report that the arms and accoutrements of the State, issued to the institution by the Quartermaster-General, and in use for the purpose of military drill, are in good order and properly cared for. The department of military instruction is under the charge of Colonel J. H. Kellogg, Brevet Major United States Army, and the Board witnessed, with satisfaction, the drill of the company.

The Board report that the terms of office of Mr. Freeman, in the third district, and Mr. Colt, in the fourth district, as members of this Board, will expire April 12th, 1870.

WILLIAM H. HENDRICKSON,
President.

WILLIAM PARRY,
Secre ary.

TRUSTEES' REPORT.

To His Excellency Theodore F. Randolph, Governor of the State of New Jersey:

SIR:—I beg leave, in behalf of the Trustees of Rutgers College, to submit the fifth annual report of Rutgers Scientific School, in accordance with the requirement of the fourth paragraph of section fifth of the act of Congress, approved July 2, 1862, and section fifth of the act of the Legislature of the State of New Jersey, approved April 4, 1864.

It gives me great satisfaction to state that the condition of the school is steadily improving, and is now decidedly better than at the date of any previous report.

I. FACULTY OF RUTGERS SCIENTIFIC SCHOOL.

The Faculty is now constituted as follows:

Rev. William Henry Campbell, D. D., LL. D., President, and Professor of Moral Philosophy.

George H. Cook, Ph. D., LL. D., Vice President, and Professor of Chemistry, Natural History and Agriculture.

David Murray, A. M., Ph. D., Professor of Mathematics, Natural Philosophy and Astronomy.

Rev. Theodore Sandford Doolittle, Professor of Rhetoric, Logic and Mental Philosophy.

Colonel Josiah Holcomb Kellogg, Brevet Major, United States Army, Professor of Civil Engineering and Military Superintendent.

John Conover Smock, A. M., Professor elect of Mining and Metallurgy.

George W. Atherton, A. M., Voorhees Professor of History, Political Economy and Constitutional Law.

Rev. Carl Meyer, D. D., Professor of French and German.

Francis Cuyler Van Dyck, A. M., Tutor in Chemistry.

Isaac Edgar Hasbrouck, A. M., Tutor in Mathematics.

Professor Smock, well known in connection with the Geological Survey of this State, is now in Germany, but is expected to enter upon his duties in the Scientific School next September.

II. COURSES OF STUDY.

The Scientific School provides two distinct courses of study, either of which the student may elect for himself.

I. A COURSE IN CIVIL ENGINEERING AND MECHANICS.

II. A COURSE IN CHEMISTRY AND AGRICULTURE.

These courses extend through three years. The studies of the first year are the same in both, and are arranged with particular reference to the wants of those who desire, within a limited time, to prepare themselves as Land Surveyors.

A SPECIAL COURSE in Chemistry is also provided to meet the wants of such students as wish to devote themselves exclusively to this branch.

In addition to these regular courses, provision is made for PARTIAL STUDENTS, who may enter at any time and select, under the direction and advice of the Faculty, such studies as they may be found qualified to pursue with classes already formed, subject to the general regulations and discipline of the Institution, and to such examinations as may be prescribed in each case. Such students, on leaving the Institution, receive certificates stating the studies pursued and the attainments made.

III. TERMS OF ADMISSION.

Applicants for admission to the full courses of study must be sixteen years of age, of good moral character, and must pass a satisfactory examination in English Grammar and Spelling, Geography, Physical Geography, History of the United States, Arithmetic, Algebra to Equations of the Second Degree, and three books of Plane Geometry.

Candidates for advanced standing are examined, in addition to the preparatory studies, in those already pursued by the class they propose to enter.

IV. CLASSES AND THEIR EXERCISES.

The classes now in the Institution are:

First—The class organized in September, 1867, which will be graduated in June, 1870.

Second—The class organized in September, 1868.

Third—The class organized in September, 1869.

The first class now consists of seven students; the second of twelve students, and the third of sixteen students—making a total of thirty-five.

There have been in the Institution, during the year, fifty-three students; of whom three were from the State of New York, one from Pennsylvania, four from Japan, and the remaining forty-five from the State of New Jersey, representing the counties as follows:

Bergen county,	1
Cumberland "	2
Essex "	7
Mercer "	4
Middlesex "	13
Monmouth "	5
Morris "	5
Passaic "	1
Somerset "	6
Union "	1

The courses of study are given in full in Appendix A., but the following table shows the distribution of them and the number of recitations per week in each:

	Subjects.	Hours per week.
FIRST CLASS.		
Winter Term. (Jan. to April, 1869.)	Chemical Physics,	4
	Geodesy,	2
	Drawing and Engineering,	8
	Political Economy,	3
Spring Term. (April to June, 1869.) Graduated, June 23.	Geology,	3
	Architecture,	2
	Field Fortifications,	3
	Stone Cutting,	3
	International Law,	4
	Chemistry.	3
Fall Term. (Sept. to Dec., 1869.)	Moral Philosophy and evidences of Christianity,	4
	Mechanics and Engineering,	7
	Organic Chemistry,	1
	Constitution of the United States,	2
	German,	3
SECOND CLASS.		
Winter Term.	Inorganic Chemistry,	2
	Differential and Integral Calculus,	3
	Shades, Shadows and Perspective,	3
	Metaphysics,	4
	German,	3

	Subjects.	Hours per week
SECOND CLASS. Spring Term.	Mechanics and Drawing,	6
	Optics and Acoustics,	3
	Constitutional History of England,	5
	German,	3
Fall Term.	Chemistry,	1
	Railroad Curves with Field Exercises,	4
	Analytical Geometry,	4
	Shades, Shadows and Perspective,	3
	Rhetoric,	2
	German,	2
	Blowpipe Analysis.	1
THIRD CLASS. Winter Term.	Modern History,	3
	French,	4
	Geometrical Drawing,	3
	Trigonometry,	4
	Algebra,	3
Spring Term.	Modern History,	2
	Botany,	2
	French,	4
	Geometrical Drawing	2
	Descriptive Geometry,	4
	Surveying, with Field Exercises,	5
Fall Term. Entering Class.	English Literature,	3
	French,	2
	Physiology,	2
	Geometry and Geometrical Drawing,	4
	Algebra,	3

Besides the attention given to Military Engineering and Field Fortifications by the Graduating Class, as above exhibited, the members of all the classes are drilled by the Military Superintendent, during the autumn and summer terms, in Infantry Tactics, including the manual of arms. The arms and accoutrements, furnished by the State for this purpose, are properly cared for in the armory provided by the Trustees and are now in good condition.

V. THE LAST GRADUATING CLASS.

At the last Commencement of the College, in June, 1869, the Graduating Class, consisting of nine members, was admitted to the

degree of Bachelor of Science. Theses were prepared by them and read before the State Board of Visitors, on the following subjects:

Nathaniel Board, Pompton, N. J., "Canals."

Simeon E. Bucknall, New Brunswick, N. J., "Geological Changes Effected by Water."

Holmes Van Mater Dennis, Marlboro, N. J., "Railroads."

Joshua Doughty, Jr., Somerville, N. J., "Agriculture."

J. Ridgway Fell, Trenton, N. J., "Strength of Materials."

Edward Sealy, Madison, N. J., "The Railroad Bridge over the Passaic at Newark."

Augustus Vanderveer, Rocky Hill, N. J., "Mineralogy."

Wm. Augustus Van Mater, Holmdel, N. J., "Astronomy."

Abram De Hart Voorhees, Six-mile Run, N. J., "Agriculture."

The two prizes offered by the Professor of Mathematics for the best theses were awarded, the first to Mr. Sealy, the second to Mr. Bucknall.

A prize of one hundred species of minerals offered by the Professor of Chemistry to the member of the Graduating Classes who should be able to identify and name the largest number of them was awarded to Mr. Doughty.

The demand in every department of industry for men of trained intelligence, is shown by the fact that all the members of this class have already found honorable and remunerative employment in the work for which they had prepared themselves; and all, with a single exception, are employed in New Jersey, thus giving the State a direct return for her care of this Institution. Two of the class are engaged in farming; one in surveying; three in new railroad enterprises; two upon railroads already established, and one as Assistant Engineer of Indianapolis (Indiana) City Water Works.

VI. AGRICULTURAL DEPARTMENT.

The condition of the Agricultural Department is fully exhibited in the following report of Dr. Cook, to which I invite particular attention. It shows that the Trustees have been and now are making every effort to carry out as fully as possible the designs of the National and State Governments in the establishment of this and similar institutions, and these efforts are already securing important benefits to the people of the State, with the promise of still greater usefulness hereafter.

New Brunswick, Dec. 1, 1869.

Rev. W. H. Campbell, D. D., President of Rutger's College:

Dear Sir:—Herewith I submit my report upon matters connected with the Agricultural Department of this Institution.

I. AGRICULTURAL COLLEGE LECTURES.

The law establishing the Agricultural College requires that at least one lecture on agriculture shall be given in each county of the State, every year, by a Professor from the College. This duty has been attended to, and in one or two of the counties, at the request of friends of agriculture, several lectures have been delivered. These lectures are elementary, but as many of their illustrations are drawn from circumstances peculiar to the State, they have a local interest, and supply information to our farmers which they could not otherwise obtain.

The lecture for the present year is upon *Agricultural Chemistry*. In the delivery it was illustrated by chemical experiments. The various topics discussed were also explained by references to the composition of soils, fertilizers and various farm crops. The original matter in these lectures, and their extensive circulation when printed by the Legislature, make them an efficient agency in the cause of agricultural education. They become, too, a means by which communication between the Agricultural College and the various Farmers' Clubs in the State can be kept up, and the matter contained in the lectures be brought to the notice of our most enterprising and progressive farmers.

The lectures have been followed, in several instances, by the formation of Farmers' Clubs, and it will be a great benefit to farmers to establish these in every part of the State. The Professor of Agriculture is always ready to answer inquiries, and to furnish information that may be needed in carrying out the work of these useful associations.

II. EXPERIMENTAL FARM.

"To provide a suitable tract of land conveniently located, for an 'Experimental Farm,' without charge to or upon this State," was one of the terms required of the Trustees of Rutger's College. This condition is being carried out. A tract of land, containing one hundred acres, was purchased; this was afterwards diminished by six acres, which were taken off for the reservoir of the city water-works. It has since been increased by the purchase of five acres more, so that the farm now contains ninety-nine acres. The location of the land is

as convenient as it can be, lying on the south side of the city, and partly within its limits, and the farm-house on it being only about three-quarters of a mile from the centre of the city, while the graded streets, street-lamps, and city water-works extend quite out to the farm. The distance from the college buildings to those of the farm is one and a-half miles. As an experimental farm, this tract presents great advantages. It was, when purchased, an old-style farm, part dry, tillable land, but extremely poor; part pasture land, too wet and heavy to be fit for tillage; and part in stumps, sprouts and young timber.

The first efforts upon the farm were of course directed to bringing its whole area into profitable cultivation, by draining the wet grounds, clearing and breaking up those which had never been plowed, and enriching the whole by manures and tillage. Twenty-four acres of land have been thoroughly underdrained; twenty-five acres of new land have been broken up and partially cleared of stumps; one thousand two hundred and fifty bushels of gas lime, five hundred tons of greensand marl, and considerable quantities of stable manure, superphosphate of lime, bone dust, poudrette, guano, &c., have been used upon the farm for enriching it. The bringing of such land into productive cultivation is a tedious and expensive work, and the expense of this has been materially enhanced by making an effort to accomplish the needed improvement at the earliest possible time, so as to get the farm into its proper use of testing fertilizers, seeds, crops, modes of tillage, implements, stock, &c. In hastening this work, much more money has been spent than would be justifiable in the case of one farming for profit only, but with the eyes and the hopes of so many agriculturists upon us, we have thought it best to press the work of preparation as much as possible.

During the year 1869, the farm has received various donations from friends, as follows:

Fairbanks & Co., Scale Manufacturers, of New York city, a large platform scale, capable of weighing from one pound to six thousand pounds; with double poise bar. This adjunct to the farm implements is almost indispensable to the careful conducting of experiments on fertilizers, crops and stock. It is an excellent and accurate scale, and is in very frequent use.

Rev. G. C. Schenck, of Marlboro, a potato-plough, for digging potatoes. It was not received till after the potatoes were all dug, so that we had no opportunity to test this simple, useful and original implement.

Geo. W. Pressey, of Hammonton, on deposit, one of his Pioneer stump-pullers. This efficient machine is warranted to lift a weight of thirty-five thousand pounds, and is worked by two stout men. It is a very excellent implement, as we find by trial.

Samuel L. Allen, of Cinnaminson, one Planet hand drill for seeds

and fertilizers. This implement did its work well. It is capable of carrying and distributing fertilizers in the drill accurately.

The Freehold and Squankum Marl Company, one hundred and fifty tons of their Squankum marl from Farmingdale.

The Vincentown Marl Company, forty tons of their marl.

The Pemberton Marl Company, twenty tons of marl from their pits.

The Cream Ridge Marl Company, fifty tons from their pits near Hornerstown.

These liberal donations of marl have all been used upon the farm grounds. They produce good results upon grass, when used raw, and they give permanent fertility to the soil.

This invaluable fertilizer deserves to be more widely known and its properties more thoroughly understood. The generous aid of the marl companies is helping to make the Agricultural College Farm a conspicuous example of the benefits of greensand marl.

Russel Coe, Esq., of Linden, has given a ton of his super-phosphate of lime.

Hon. Wm. Parry, of Cinnaminson, has sent six each of the Concord, Hartford Prolific, and Ives Seedling grape-vines. These are the best known varieties for general out-door cultivation.

Charles Elkins, Esq., New Brunswick, has sent a number of plants of the Mammoth cluster raspberry.

Daniel M'Laury, Esq., New Brunswick, has given plants of Schenck's, Colfax's and Peake's new strawberries, and of the Mammoth cluster raspberry.

J. H. Whitlock Esq., Matawan, has sent a half barrel of Manhasset potatoes. This is a new white potato, of excellent quality for the table. With us it was rather slow in maturing, and the extreme dry weather came on when the vines were in luxuriant growth. By this premature ripening the crop was much injured, and the yield was not large.

S. B. Conover, Esq., of West Washington Market, N. Y., sent a package containing two pounds of the Early Mohawk potato. This is a large light red potato, said to be earlier than the Early Rose and of better quality. They came too late for early planting, but grew luxuriantly and yielded well, though damaged by the drouth. Nearly two bushels were obtained from the seed. It is a rather solid potato when cooked, but of good quality.

We have also received from Mr. Conover a box containing two hundred plants of his colossal asparagus. This is a new variety of asparagus, remarkable for the size of its shoots.

Dr. Theophilus T. Price, Tuckerton, presented a bushel of barley for seed. The object of trying this was to see if it would prove a more certain crop than oats. The experience of this year is not favorable, but it will be tried again.

The Department of Agriculture, at Washington, sent us packages

of Tappahannock wheat, Excelsior oats, Black Swedish oats, White Schonen oats and two varieties of barley.

The early crops of the past season were good. The hay crop, both of clover and timothy was very heavy. The wheat on the old cultivated land was good, yielding twenty-four bushels to the acre. The early Goodrich potatoes which ripened before the drouth, yielded, with good cultivation, two hundred bushels to the acre; the late potatoes were much injured by drouth. The corn that was acclimated here was not injured by the dry weather and yielded fifty bushels to the acre. The large gourd-seed corn was in the midst of its growth when the dry weather came on. It was greatly damaged, being little more than a half crop. The crop of cabbage, turnips, beets and carrots, was damaged to the amount of one-half, and perhaps more than that.

The stock of cattle upon the farm is approaching the pure Ayrshire. There are now five cows, a bull, a yearling heifer, and two calves of that breed. The cows are proving themselves superior as milkers to any others that we have tried. Our plan is to increase the herd until it is as large as the farm can support; and to use it in supplying milk for the market, and in raising pure-blooded animals.

The experiments with fertilizers, have been much affected by the excessive drouth, but some of them are instructive. A comparison was made between E. F. Coe's (1), and Rhodes' super-phosphates of lime (2), upon a plot of ground of very uniform quality that had previously been cultivated in potatoes. The field was sown to wheat and dressed with the super-phosphates at the rate of 400 pounds to the acre. By analysis, E. F. Coe's fertilizer contains 8.8 per cent. of soluble phosphoric acid; 5.7 per cent. of insoluble phosphoric acid and 3 per cent. of ammonia.

Rhodes' contains 7 per cent. of soluble phosphoric acid, 13 per cent. of insoluble phosphoric acid, $\frac{17}{100}$ of one per cent., a mere nominal quantity, of ammonia.

They are both honestly prepared super-phosphates of good reputation, and the object was to see if that containing only phosphoric acid produced as good effects as that containing ammonia in addition. There was a slight difference in the color of the wheat, that on the part (1), being a little the darkest as well as the largest leaved, but as it headed out and ripened no difference could be seen; and at harvest the unthrashed straw of (1) weighed 1750 pounds, and that of (2), 1750 pounds. After thrashing, the grain from (1) weighed 595 pounds and that from (2), 590 pounds. At the present time no difference can be seen in the grass on the two parts.

A comparative trial was also made between super-phosphate of lime containing 5.3 per cent of soluble phosphoric acid, 8.2 insoluble phosphoric acid, and 1.3 per cent. ammonia; bone dust containing

15.5 per cent. of insoluble phosphoric acid, and 3.2 per cent. of the elements of ammonia, and horn dust which contained 15.6 per cent. of the elements of ammonia and no phosphoric acid. The trial was made upon wheat on extremely poor ground that had been recently underdrained, and had received a light dressing of gas lime worked through the soil. The soil was of uniform quality, a very poor and sour clay-loam. That dressed with super-phosphate, 480 pounds to the acre, was the most even in its growth, of a yellowish green color, and ripened earliest. The timothy and clover both grew well, but the clover is by far the most luxuriant. The wheat and straw weighed 1,655 pounds, and the wheat alone 483 pounds.

The bone-dust shows the least effect, the wheat and grasses were thin and uneven, though of the same general appearance with the last. The dressing was 500 pounds to the acre. The wheat and straw weighed 960 pounds, and the wheat alone 240 pounds.

The horn-dust shows the effect of a pure ammoniacal manure. The wheat was uneven but in part of luxuriant growth, the blades being broad and very dark green. It did not ripen as early as the preceding. But the most remarkable peculiarity is, that scarcely a leaf of clover is to be seen, while the timothy is very large and when the wheat was harvested was almost a full crop. The unthreshed straw weighed 1,375 pounds and the wheat 340. The grain on all the plots was much damaged by rust.

Experiments are in progress with composts of marl and barn-yard manure, and our experience is that they are more effective than the same value of either separately. Heaps of compost are in preparation for next year's crops, and some accurate results will be arrived at. A very powerful fertilizer has been made by the use of a compost of refuse meat and marl; no other fertilizer used on the farm has produced such active effects.

For the valuation of manures, reference may be made to the Agricultural Lecture accompanying this report (Appendix B), and attention is asked to this subject, because the full worth of manures is not adequately appreciated by farmers. All the experience on the College Farm goes to show that *there is no profit in cultivating poor land.* Either make the land rich by means of manures, or do not waste labor in the attempt to till it. Raise clover, keep stock, or buy manure. One or the other of these must be done or the farmer cannot raise paying crops.

The important question of deep and shallow ploughing and that of surface manuring are being submitted to trial on the farm, and will be reported on in due time.

The preparatory work of getting the farm in good order has necessarily delayed the attainment of the best results of tillage: The work of preparation, however, is being thoroughly done; the effects of underdraining are very marked and satisfactory. We have had this season fifty bushels of shelled corn to the acre on ground which two

years ago was a maple swamp. We have fine grass and clover on a dry and mellow field, which, two years since, was so wet that it could not be plowed. And the old-style farm of one-third tillable land, one-third pasture and one-third woods, is soon to be a farm, every foot of which is plowed in its rotation and made to yield its share of the profits.

Respectfully, yours,

GEORGE H. COOK.

It may be added to the above, that the Trustees have considered it no part of their duty to turn the Agricultural Department into a school of manual labor. They have, from the beginning, proceeded upon the theory that while the practical applications of science should be carefully kept in view, in a course of instruction, yet that the main business of a scientific school must be to teach scientific principles and the methods of scientific investigation; and that persons who desired to become skilled in the actual operations of farming, must do it by engaging in the daily routine of a farmer's work. It is gratifying to find that their theory and practice thus agree, in two important particulars, with what the eminent Baron Liebig has recently stated to be the almost unanimous conviction among the best scientific agriculturists of Europe; viz., that the Agricultural College ought always to be connected with institutions devoted to other departments of instruction, and that the attempt to keep up a system of manual labor had been proved to be impracticable, being now universally abandoned as a failure. No objection can be made, however, to providing labor, as far as possible, for students who may wish in this way to help themselves; and it is hoped that the condition of the farm may soon be such as to furnish a considerable demand for voluntary labor of this kind.

VII. EXTENSION OF THE COURSE.

The aim of the Scientific School has been, from the first, to maintain a course of instruction equal in extent and thoroughness to the best. The addition which has already been made by the Trustees and the Board of Visitors to the original conditions for admission, has proved to be an important step in the right direction. Our students now come to us much better prepared than at first, and are consequently able to devote their time more largely to the higher branches of study in their various departments. Experience has shown, however, that notwithstanding the advantage thus gained, a three years' course, as now provided for, is too short for the work that is to be done. The result is either an omission of some important subjects or part of subjects, or a pressure of overwork upon the students. The two remedies possible are, a still further and very large addition to the conditions for admission, or an addition of one year to

the regular courses in the scientific school. The latter seems on nearly every account the most advisable, and the Faculty have unanimously and with great earnestness, recommended this change to the Trustees. They have not yet acted upon the subject, but it is expected to come up at an early day. If the course should be thus extended, it is proposed, in order to meet the wants of those who may be unable to remain so long as four years at study, to arrange the studies of the first two years as a course complete in itself. This short course would be sufficient for those who wished to become land surveyors, or practical workers in any one of the leading branches of industry, while the full course would fit men for the higher departments of mining, engineering, architecture and other scientific pursuits.

There can be no doubt that the increase of range and thoroughness and consequent value thus given to the course of study, would be far greater than in proportion to the increase of time; and the Faculty have come to consider the measure very important to the highest usefulness and success of the institution. Their purpose is to make the scientific course as valuable in its way as the classical is in its way, and to make it answer, as far as possible, every requirement of a truly liberal course of education. They wish not merely to turn out accomplished specialists, but to furnish a body of men trained in the best principles and methods of investigation, and equally able to accumulate knowledge or to use it for the welfare of the community.

The amount received from the State Treasury for the fiscal year ending November 30, 1869, is $6,924, which has been expended exclusively for the salaries of the professors in the scientific school.

All which is respectfully submitted.

WM. H. CAMPBELL, *President.*

New Brunswick, December 2, 1869.

APPENDIX.

APPENDIX A.

COURSES OF STUDY.

I.—COURSE IN CIVIL ENGINEERING AND MECHANICS.

FIRST YEAR.

First Term.

1. Loomis' Algebra, from Quadratic Equations.
2. Loomis' Geometry, from Book IV.
3. Draughting; construction of Problems.
4. Lectures on Physiology.
5. Elocution, Composition and Declamation.
6. French.

Second Term.

1. Algebra and Geometry finished.
2. Trigonometry, Plane and Spherical.
3. Geometrical Draughting.
4. Zoology, History, French, Composition and Declamation.

Third Term.

1. Surveying, with Field Exercises—Descriptive Geometry.
2. Draughting.
3. Botany, History, French.
4. Composition and Declamation.

SECOND YEAR.

First Term.

1. Analytical Geometry.
2. Leveling and Railroad Curves.
3. Shades, Shadows and Perspective.
4. Elements of Chemistry and Mineralogy.
5. Mental Philosophy, German, Composition and Declamation.

Second Term.

1. Differential and Integral Calculus.
2. Physics and General Chemistry.
3. Shades, Shadows and Perspective—Construction of Problems.
4. Mental Philosophy, German, Composition and Declamation.

Third Term.

1. Bartlett's Mechanics.
2. Bartlett's Optics and Acoustics.
3. History.
4. German.

THIRD YEAR.

First Term.

1. Bartlett's Mechanics.
2. Civil Engineering.
3. History and Constitution of the United States.
4. Moral Philosophy.

Second Term.

1. Civil Engineering.
2. Stone Cutting.
2. Geodesy and Practical Astronomy.
4. Political Economy.

Third Term.

1. Civil Engineering—Preparation of Thesis.
2. Geology—Lectures and Geological Excursions.
3. Architecture—Lectures.
4. Military Engineering.
5. International Law.

II.—COURSE IN CHEMISTRY AND AGRICULTURE.

FIRST YEAR.

[The same as in Civil Engineering and Mechanics.]

SECOND YEAR.

First Term.

1. Analytical Geometry.
2. Leveling and Railroad Curves.
3. Shades, Shadows and Perspective.
4. Elements of Chemistry and Mineralogy, with Laboratory practice.
5. Mental Philosophy, German, Composition and Declamation.

Second Term.

1. Analytical Chemistry and Laboratory practice.
2. Physics and General Chemistry.
3. Lectures on Agriculture.
4. Mental Philosophy, German, Composition and Declamation.

Third Term.

1. Analytical Chemistry, with Laboratory practice.
2. Vegetable Physiology.
3. History.
4. German.

THIRD YEAR.

First Term.

1. Mining and Metallurgy.
2. Principles of Agriculture—Farm Accounts.
3. History and Constitution of the United States.
4. Moral Philosophy.

Second Term.

1. Chemistry and Laboratory practice.
2. Agriculture—its methods and products.

3. Geodesy and Practical Astronomy.
4. Political Economy.

Third Term.

1. Geology—Lectures and Geological excursions.
2. Animal Physiology.
3. Architecture—Lectures.
4. Military Engineering.
5. International Law—Preparation of Thesis.

III.—SPECIAL COURSE IN CHEMISTRY.

FIRST YEAR.

First Term.

1. Elements of Chemistry—Text-book and Lectures.
2. Blowpipe Analysis.
3. Elements of Mineralogy.

Second Term.

1. Physics and Chemistry—Text-book and Lectures.
2. Chemical Analysis—Qualitative.

Third Term.

1. Chemical Analysis—Qualitative and Quantitative.
2. Vegetable Physiology.

SECOND YEAR.

First Term.

1. Chemical Analysis—Analysis of Minerals, Ores, &c.
2. Mineralogy—Determinative.

Second Term.

1. Chemical Physics—Heat, Electricity, Magnetism, Galvanism and Electro-Magnetism—Text-book and Lectures.
2. Analysis of Fertilizers and Chemical Products.

Third Term.

1. Lectures on Geology.
2. Chemical Analysis—Special Investigations.

APPENDIX B.

LECTURE ON AGRICULTURAL CHEMISTRY.

1869.

Delivered in obedience to the Law of New Jersey, which requires the Trustees of the State Agricultural College "to have delivered annualy, in each county of this State, one or more public lectures upon the subject of Agriculture, free of charge."

LADIES AND GENTLEMEN:—The lecture to be delivered before you to-night is upon the subject of Agricultural Chemistry.

Coming before you as the representative of the New Jersey State Agricultural College, I may be allowed before beginning my subject, to allude to the College, and the interest which every county has in its prosperity and usefulness. The institution is in operation and two classes of its graduates have already gone out to engage in the active duties for which they have prepared; and we are able to say for them that they are acquitting themselves well. Several are engaged in civil engineering, some in mechanical engineering, some are farming, and others ready for any practical business. The College is what it was designed to be, a school of preparation for those who are to engage in Agriculture or any other industrial art; and it is proving that liberal education is just as important for the farmer or mechanic, as it is for the lawyer, or doctor, or minister. Everywhere science aids art, and the efficiency of the hand is increased by the intelligence of the mind.

The counties of the State all have free scholarships in this institution. Those counties which have enjoyed the benefits of the College teaching, are prompt to fill any vacancies that may occur in their scholarships; but there are some parts of the State from which no students have yet been received. To such we would say, you are allowing your county to suffer a loss. The scholarship is yours; the requirements

for admission are no more than your very best schools can furnish, and your County School Superintendent has the authority to examine candidates and give them the certificates for admission. We shall be glad to have the scholarships from your county all filled, to have your young men go through their course with honor, and then come back here to use their education for the benefit of your whole community.

The title of my lecture scarcely defines its object, and yet I have nothing better. The phrase Agricultural Chemistry is very commonly used to cover the whole ground of Rural Economy, to include everything that belongs to Agriculture, whether it be *tillage*, *manures*, *stock raising* or the *weather*. I wish however to limit my subject to the chemical substances, which together make up the mass of vegetable matter; those of which all trees, shrubs, herbs and farm crops are composed; and the sources from which these substances are derived.

The first point which I desire to present is, that the main part of all vegetation is composed of carbon and the elements of water, and is drawn from the air. To illustrate this I burn a splinter of dry pine wood and hold this glass test-tube with its mouth downwards over the blaze. You see the inside of the tube is covered with a mist or dew; that water has been formed from the burning wood. This however soon dries off, and the tube appears just as before. I shall, however, show you that the carbon of the burned wood is in the tube, though you do not see it. Here is a vial of lime water, perfectly clear, as you see, I pour it into the tube, and shake it smartly, and the water becomes as white as milk; the carbon in burning combined with the oxygen of the air and formed carbonic acid, an invisible gas, like the air; but unlike the air in that it whitens lime water. The whiteness is caused by the carbonic acid combining with the lime in the lime-water to form carbonate of lime. This carbonate of lime will soon settle in the water, and when examined is found to be exactly like chalk. That the *air* will not whiten lime-water I show you by taking a test-tube containing air and pouring lime-water into it, and then agitating it, when you can see it is not sensibly whitened.

If you look again at the burned wood there is only a little ash left, so little that it can hardly be weighed. In the case of pine wood this amounts to only $\frac{3}{10}$ of one per cent. of the wood. Other kinds of wood may yield more, as for example the grapevine, which when burned, leaves $2\frac{7}{10}$ per cent. of ash; and some of our cultivated crops yield a still higher per centage, thus, wheat ranges fron 1.5 to 3.1; Indian corn from 1.3 to 2.1; potatoes from 2.6 to 8.; and beets from 2.8 to 11.3 per cent. In any case, however, you perceive there is but a small per centage of vegetable and indeed of animal matter too, but what can be burned up; that is, can be changed into gaseous matter. The ash alone remains after burning; and as earth will not burn we may conclude that the ash in the plant came from the earth, and that the other and larger part came from the air.

The oil burning in our lamps, and also the alcohol in this lamp, are both of vegetable origin,—and as they burn they form carbonic acid, which escapes into the air. With a test tube I make the same experiment over these flames that was made with the burning pine wood, and on adding lime water they show carbonic acid just as the other did. And the same experiments can be shown by collecting the carbonic acid from one's own breath. I put lime water in a test tube, and then with a very slender tube blow a stream of air from my lungs through the lime water, and an immediate whitening of the lime water takes place. This shows the existence of carbonic acid in my breath. It was not in the air you saw, then it must have been made in my lungs. And it is a fact, that in some way the oxygen of the air combines with the carbon of my body and forms carbonic acid. You see too that it is attended with the same effect as in the lamp; heat is developed and my body is kept warm. The warming of the body by the action of the air on the animal substance in the lungs, is just as fair an example of heat developed by chemical action, as is the warming of a stove by the combination of coal and oxygen in it. The wonderful difference between them is that our bodies are always of the same warmth, while in the blaze the heat may be much more intense at some times than at others. It may seem to you as if the change going on the lungs is not enough to produce such an effect. But if I were to continue this process of breathing out through the lime water all day, and there were enough of it, you would find that more than five pounds of this chalk-like sediment would form in twenty-four hours, a quantity which represents ten or twelve ounces of carbon.

In all these experiments you see the carbonic acid is going off into the the air. In the experiment of agitating lime water and air together in the test tube, you saw that there was no whitening effected. There *is* carbonic acid in the air however, only it needs nicer experiments than that to show it. Now, when I take a wide and open vessel like this bell-glass, and put a little lime water in it, you see the carbonate of lime soon forms and the water becomes white. The carbonic acid here shown was not all in the air of the bell-glass, but the atmosphere is so wonderfully constituted that if a gas of any kind is set free at any part of it, the gas soon finds its way to every other part; and in this experiment the carbonic acid in the air next the lime water is absorbed, and then that farther off comes in to take its place—and this process would continue, and the gas would be drawn from the air further and further the longer the experiment was continued.

It is shown that the various substances burned or consumed produce carbonic acid, and that it is in the air. I must next show you that there is an abundance of it in the air, and that it can easily be got out to use as the food of growing plants.

By taking a measured portion of air and carefully precipitating the carbonic acid in it by lime water, and then drying and weighing it, as

the chemist knows how to do, it is proved that about twenty-five hundred pounds of air contain one pound of carbonic acid. Now, every square foot of surface of the earth has about one ton of air pressing down on it; we may say that each square foot of the earth's surface, both land and water, has about one pound of carbonic acid over it. As an acre contains 43,560 square feet, it follows that there must be more than 40,000 pounds or twenty tons of this gas over every acre of ground. This now is enough to supply the food for a heavier crop than ever grows upon an acre in a single year.

To show how fast this gas can be absorbed from the air, we had a board whitewashed with lime in the common way, and at the end of three and a half days (which happened to be a convenient time) had the whitewash carefully scraped from a square foot of it, and then found by analysis how much carbonic acid had been absorbed. It proved to be 55.5 grains; at the same rate for an acre this would be 345 pounds, or almost 100 pounds an acre every day. It will be profitable to stop a moment for the explanation of this experiment. Fresh burned and slaked lime contains no carbonic acid at all, as you see by this experiment of putting some fresh slaked lime in the test tube and wetting it, and pouring on some muriatic acid. The lime dissolves quietly in it and there is no effervescense or escape of gas whatever. But if I take some whitewash or mortar from the wall and put this in the test tube, and pour muriatic acid on it, there is a quick effervescence and foaming up caused by the escape of the gas in it, which soon fills up the tube and runs over in froth. This gas has been absorbed from the air. It hardens the mortar, you see, and it has also purified the air. The old fashioned process of whitewashing was a cleansing and purifying one, as you see by this experiment.

The estimate from whitewashing showed how much carbonic could be taken out from the air. I do not mean to say, however, that this is the chief substance to be used in absorbing carbonic acid for the supply to vegetation. Water absorbs this gas, so brings it down to the earth in the rain which falls. Leaves of plants have the power of absorbing carbonic acid from the air, and a large supply is obtained in this way. All the carbon in plants was first derived from the air, but it is not intended to say that the air will at once supply all that is needed for a large crop, for all experience proves that a much greater product can be raised from a soil which contains much vegetable matter than from one which is destitute of any such matter. But it is intended to say that the great supply comes from the air, and that it is in the power of the intelligent farmer to increase his supply by favoring its entrance into the soil. A chief object of tillage is to put the soil in condition to receive and be acted on by the air and the gases it contains. For this reason we plough the soil, we harrow and rake it, we sub-soil plough or underdrain it, we break up the little hard crust which forms on it by the pattering of the rain,

and all, so that it may receive the air, and so that the rain that falls on the surface may sink into the soil and there be filtered by the earth and made to leave everything enriching that it contained, for the benefit of the growing crops. How much thorough tillage can do was well shown by the teachings of Jethro Tull, an Englishman devoted to the improvement of agriculture, who wrote about a hundred years ago. He was the inventor of the drill and used the horse hoe. He believed that thorough tillage and pulverization of the soil was sufficient for raising good crops without manure, and his experiments go far to prove the correctness of his theory. He was very successful in his practice, and though he failed to prove his principles he drew the attention of farmers to the great importance of thorough cultivation of the soil, and his influence is felt to this day.

The supply of carbonic acid being thus provided for, we have disposed of the largest constituent of vegetation.

It remains then to speak of the ash or earthy matter in plants; to inquire of what it is composed, and whence its elements can be supplied. The ash is not in quality or proportions like the earth from which it was drawn, but is uniform in quality when from the same kind of plants, and contains very little of the substances which compose the large part of soils. In the principal constituents of the soil there is much uniformity. There is a tract of country in the eastern part of Burlington county, called the Plains, which is so poor that trees have never grown upon it, and it is not worth cultivation, and on the contrary, the soil in the lime stone valleys of Sussex and Warren counties is so rich that cultivation for a hundred years without manure, has not exhausted its fertility, and yet when we examine the amount of sand, clay, oxide of iron or vegetable mould in these soils, they are not found to differ materially. The fertility of soils, that is their power of supporting crops is dependent on the existence of small quantities of a very few substances. Many experiments have been made within a few years past to determine exactly what these substances are. There is a little book entitled *Six Lectures on Agriculture*, by M. George Ville, published under the direction of the Massachusetts Society for promoting Agriculture, which gives an account of the way in which M. Ville experimented to reach his conclusions, first upon poor sand in flower pots, then upon the Emperor's farm at Vincennes, and finally upon the sands of the *landes* in Gascogne. His conclusions, however, were, that phosphoric acid, potash, lime, and nitrate of potash (or other nitro-genous substance) in the soil are essential to the growth of good crops; that without phosphoric acid "vegetation is not possible," and that without the other constituents it is not possible to raise healthy and luxuriant crops. He gives the composition of what he styles a *complete manure*, for one acre of ground. It is as follows:

Phosphate of lime, (fine ground bones,)	352	pounds.
Carbonate of potash, (pearl ash,)	352	"
Quick lime, (slaked lime, dry,)	132	"
Nitrate of soda, (as nitro-genous matter,)	488	"

With this manure he asserts that good crops can be raised on soil previously barren; and that upon ordinary soils the fertility can be kept up by the addition of one or other of these substances, according to the nature of the soil and the crop to be raised.

How Crops Grow,—a sound, practical and reliable book for farmers, by Professor S. W. Johnson, of Yale College, also gives very full particulars of the modes of experiment pursued by different vegetable physiologists, to settle the point in question.

Water-culture, or raising the plants in water containing the requisite mineral substances, was the method to which he ascribes the best results. He says that "potash, lime, magnesia, phosphoric acid and sulphuric acid are absolutely necessary for the life of agricultural plants, as is demonstrated by all the experiments hitherto made for studying their influence."

We may safely accept the conclusions of these writers, and to reduce them to practice may enquire: Where, and from what sources can New Jersey farmers get these indispensable substances.

And first, of *phosphoric acid*. At present, all our supplies of this substance are from its compound with lime, forming phosphate of lime. It is the mineral substance of the bones of animals, is found in various insoluble guanos, exists as an extensive geological layer in the earth about Charleston South Carolina, is a constituent of our New Jersey green sand marls, and is also found in other substances and places. When the value of this substance, as a fertilizer, was first established, ground bones were resorted to, but they are so hard to dissolve that it took an immense quantity to fertilize a single acre. You know that whole bones may lie exposed to the weather for years without being lost, and when buried in the ground they remain for ages. The finer they are ground the faster they will dissolve, and mechanics are constantly at work to invent mills which will do this satisfactorily. But the finest *flour of bone* has its particles of some perceptible size. Liebig, the eminent German chemist, invented a method of making *super-phosphate of lime* in which the phosphate is made very fine by chemical action. Sulphuric acid is added to the bone phosphate of lime, and by combining with part of the lime, it leaves the phosphoric acid and the remaining part of the lime soluble in water. This was a grand step in advance; it increased the quickness of action of the phosphate, and made it possible to extend its use over a very much greater area of country. This fertilizer is now made from bones, burnt or raw, from phosphatic guanos, and from mineral phosphates.

I have said that the super-phosphates would dissolve in water. They do, and of course, when spread upon the ground, the first

rain that comes dissolves them, and carries them everywhere through the soil, just as the rain-water goes. As the super-phosphate passes into the soil, it comes in contact with lime, alumina and oxide of iron, and is again restored to the condition of insoluble phosphate, or bone-earth; but it is wonderfully fine—finer a thousand times over than the best mill could grind it. It is then vastly easier to dissolve and to furnish plant-food to the roots of growing vegetation.

It is worth while to stop here and show one or two experiments to illustrate the importance of *fineness* in the particles of soils or of fertilizers. I take a test-tube and pour a little lime-water into it, and then blow my breath through the water till it is white with carbonate of lime. This carbonate of lime does not differ at all in composition from marble or limestone, or oyster or clam shells, only it is very fine. Now if I take this whitened lime-water and pour into it water in which carbonic acid is absorbed, the water again becomes clear; the carbonate of lime is dissolved. I could not do this with ground limestone, or chalk, or oyster shells, if I were to continue the attempt for hours. It is the fineness of the particles which makes them dissolve so easily. I have occasionally found men who seriously proposed to grind limestone, to use as a fertilizer—and I have known of the experiment being tried in Sussex. I saw a mill at work in Cape May grinding clam shells for a manufacturer of fertilizers, and lately I received some samples of soft slaty limestone from Central New York, which is there being ground and sold for a fertilizer, at prices nearly the same as for plaster. All such work is a waste of labor. No mill can make lime so fine as it can be made by burning and slaking, or do the work so cheaply; and if it is mild lime or lime combined with carbonic acid that is needed, this may be got by leaving the lime to air-slake and absorb that gas from the atmosphere. The experiment just shown is interesting to the farmer, as it exhibits in a striking way the agency of the carbonic acid in rain water, in dissolving the solid particles of the soil.

Another experiment now will show you that the phosphate of lime in the soil can be dissolved by water containing carbonic acid, just as the carbonate of lime was. Here is a clear solution of super-phosphate of lime. It was made by soaking common super-phosphate in pure water, and then draining the water off. I pour some lime-water into this solution, and you see there is a white precipitate formed immediately. This precipitate is bone-earth, or insoluble phosphate of lime. Now if I pour into this, water in which carbonic acid is absorbed, the phosphate of lime is dissolved and the liquid becomes clear again. This is another instance of the powerful and important agency of the carbonic acid of the air. And thus we see how much work the farmer can make it do under his intelligent guidance; and we see too, the importance of having the bone-earth fine.

Before proceeding further in my explanations, I will show you a tabular statement of the gold values of some of the substances men-

tioned as being essential to plant-growth. The table was prepared by Stockhardt, a German Chemist, and I copy it from Caldwell's Agricultural Chemical Analysis. The prices have been determined by ascertaining the lowest rates at which the substances can be purchased in commercial forms.

Form in which the substance exists in the fertilizer.	PRICE PER LB. IN GOLD.
Phosphoric Acid, soluble in water, as in super-phosphate,	$ .12½
Phosphoric Acid in Peruvian guano,	.10
Phosphoric Acid in steamed bones finely ground, in rape cake, poudrette, etc.,	.08¼
Phosphoric Acid in Baker guano,	.07½
Phosphoric Acid in coarse bone-meal, fresh human urine, etc.,	.07
Phosphoric Acid in coarse broken bones, fresh human excrements, stable manure, etc.,	.05½
Potash as potassic sulphate,	.06½
Potash as potassic chloride and in other forms,	.05½
Nitrogen easily soluble, or in compounds that are readily decomposed, as ammonia nitrate, dried blood, meat, urea, etc.,	.22
Nitrogen in finest bone-meal, poudrette, etc.,	.19¼
Nitrogen in coarse bone-meal, rape-meal, horn-meal, wool-dust, fresh human urine, etc.,	.16½
Nitrogen in coarse broken bones, horn shavings, woolen rags, fresh human excrements, stable manure, etc.,	.13¾

The English valuation of these substances is given in Vol. 20, p. 74 of the *Country Gentleman*, by Dr. Voelcker, Consulting Chemist to the Royal Agricultural Society of England. It is as follows, allowing two cents for each English penny:

1. Nitrogen in the form of ammonia,	16 cts.	℔ lb
2. Nitrogen in animal or vegetable substances,	12	"
3. Nitrate of Soda,	4	"
4. Phosphate of Lime, (bone earth), or Phosphoric Acid alone,	2 4	" "
5. Soluble Phosphate of Lime, or Bi-Phosphate of Lime,	9	"
6. Salts of Potash,	2½	"
7. Gypsum,	2 cts.	℔ 10 lb
8. Lime,	2	" 12 "
9. Carbonate of Lime,	2	" 25 "
10. Magnesia,	2	" 10 "
11. Organic matter, (humus),	2	" 20 "
12. Common Salt,	2	" 10 "

Professor S. W. Johnson, of New Haven, Connecticut, in a "report to the Secretary of the State Board of Agriculture on Commercial Manures," made last winter, estimates the gold value of potash, at 4 cents a pound; soluble phosphoric acid at 12½ cents; insoluble phosphoric acid 4½ cents, and nitrogen 17 cents. Professor Johnson is the best authority on this subject in our country. It is to be hoped that he will extend this list of prices, until it covers all the various forms of these essential elements in fertilizers which are found in our markets.

To show how these tables of prices are used in calculating the value of a commercial fertilizer, I give the analysis, as made in our laboratory, of Bowers' Complete Manure and its value, as calculated from Professor Johnson's prices.

ANALYSIS.

Phosphoric Acid, soluble,	5.88
Phosphoric Acid, insoluble,	16.84
Potash,	9.89
Ammonia,	1.64
Lime,	24.64
Oxide of Iron and Alumina,	4.40
Magnesia,	.17
Insoluble matter,	3.20
Sulphuric Acid,	13.85
Organic matter, besides ammonia,	12.05
Water,	7.00
	99.56

Valuation of one ton (2,000 pounds.

117.6 pounds of soluble Phosphoric Acid at 12½ cents,	$14 70
336.8 pounds of insoluble Phosphoric Acid at 4½ cents,	15 15
197.8 pounds of Potash at 4 cents,	7 91
32.8 pounds of ammonia—27 pounds of Nitrogen at 17 cts.	4 59
Value, per ton, in gold,	$42 35

The value of most of the commercial manures can easily be calculated by the use of the above table when the analysis is given. Nitrogen at seventeen cents is equal to ammonia at fourteen cents nearly.

We insert here a table of the composition of fertilizers analysed in our laboratory last year:

Analyses.

	1	2	3	4	5	6	7	8	9	10	11
Soluble Phosphoric Acid. ..	8·8	7.2	5.3	3.6	7.1	5.4	0.9	0.7	....	3.8	.....
Insoluble Phosphoric Acid.	5.7	6.4	8.2	13.8	8.1	9.4	....	....	15.5	8.7	.....
Sulphuric Acid.....	17.9	19.1	17.9	12.4	14.6	18.4	....	....	9.4	17.1	.....
Lime.....	16.2	15.5	15.7	24.0	15.2	16.5	7.2	....	33.4	13.6	0.9
Magnesia.....	1.0	3.7	3.7	....	....	.....	....	....	1.5	0.8	0.2
Oxide of Iron and Alumina.	0.8	1.8	6.4	7.2	24.0	.7.6	8.1	....	1.1	2.8	.....
Insoluble Matter.....	2.0	3.2	3 0	6.5	4.8	5.8	....	....	3.5	7.4	5.8
Organic Matter.....	31.7	22.4	18.5	31.4	46.0	34.8	23.6	24.9	34.8	25.8	93.1
Water.....	16.2	18.8	20.0	....	....	3.9	10.9	5.1	....	19.3	.....
Total.....	100.1	98.1	98.7	98.9	98.2	101 8	....	....	99.2	101.3	100.0
Ammonia.....	3.0	2.3	1.3	1.0	2.5	2.7	1.6	1.3	3.2	2.4	15.6

In the above table of analyses, No. 1 is E. Frank Coe's Super-phosphate; No. 2, Lister's Super-phosphate; No. 3, Robison's; No. 4, Berger & Butz's; No. 5, Pacific Guano; No. 6, Dey's Nitro-phosphate of Lime; No. 7, Double Refined Poudrette; No. 8, Poudrette; No. 9, Dey's Bone Dust; No. 10, Shoemaker's Phuine; No. 11, Ter Heenan's Horn Dust.

An analysis of Super-phosphate from Russel Coe, of Linden, gave of soluble phosphoric acid 6.39 per cent.; insoluble, 5.36 per cent.; ammonia, 7.04 per cent.

The following analyses were made in 1867, but are here reprinted as being applicable to our present subject.

Analyses.

	(1.)	(2.)	(3.)
Soluble phosphoric acid, ...	7.01	6.72	7.00
Insoluble phosphoric acid, ...	12.96	17.48	6.12
Lime, ...	25.08	31.17	22.42
Magnesia, ...	.86		1.21
Alumina, ...	13.02	1.59	.80
Sulphuric acid, ...	14.47	17.80	9.75
Water and organic matter, ...	24.60	24.20	49.50
Insoluble matter, ...	2.50	.80	2.60
	100.50	99.76	99.40
Elements of ammonia, per cent, ...	.17	1.04	5.26

(1) is Rhodes' super-phosphate, and was sent by the agents in Philadelphia, Messrs. Yarnell and Trimble, for trial upon the College Farm.

(2) is Phillips' super-phosphate, and was furnished by Mr. James J. Conover, of Freehold.

(3) is the Cumberland Bone Company's super-phosphate, sent to me from the factory, in Saco, Maine, by S. R. Goodale, Secretary of the Maine Board of Agriculture.

Dry and unburned bones, when perfectly clean, contain very nearly 25 per cent. of phosphoric acid and 5 or 6 per cent. of ammonia. As ground and sent into market they contain more or less dirt, according to the care that has been taken in preparing them. Two samples of bone dust, from Peter Cooper's Glue Factory, contained 28.8 and 29.6 per cent. of phosphoric acid and 2.3 and 2.1 per cent. of ammonia. Phosphoric acid can be obtained from any of the sources mentioned above.

Another source, accessible to us, is in the green sand marls of our State. The following tabular statement shows the composition of the marls sent into market by the different marl companies of the State, and also some of those which are of large but more local use

Analyses.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid	1.14	3.58	2.58	3.87	1.33	1.02	2.30	2.24	2.69	2.56
Sulphuric Acid	0.14	0.97	1.89	.31	.00	.27	.00	.39	.26	0.22
Silicic Acid	38.70	53.15	59.80	54.75	46.03	50.23	57.67	50.80	49.40	51.59
Carbonic Acid	6.13	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potash	3.65	3.75	4.25	4.11	5.67	6.32	3.53	5.18	6.31	4.62
Lime	9.07	3.27	2.97	5.46	2.01	1.40	1.26	2.13	2.52	1.26
Magnesia	1.50	1.75	2.00	2.99	3.47	3.45	3.67	3.54	3.24	3.95
Alumina	10.20	8.79	6.00	6.46	7.86	7.94	10.10	8.77	8.90	6.01
Oxide of Iron	18.63	15.94	11.98	15.20	25.23	20.14	14.16	17.63	17.11	21.04
Water	10.00	8.98	8.32	6.85	8.40	9.00	7.25	9.66	9.10	7.39
	99.16	100.18	99.79	100.00	100.00	99.77	99.94	100.34	99.53	98 55

(1.) is an average of the variety of marl most largely used in eastern Monmouth. It is not particularly rich in phosphoric acid, but is remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder. In the neighborhood of the marls, where it costs little more than the cartage, a great deal is used which is much poorer than this; but there is no trouble in finding millions of tons of this quality. It is used in larger quantities per acre than the other

varieties, and is remarkable for the permanent improvement it makes in the soil.

(2.) is an average of five analyses, of the *Squankum* marl, and may be taken as a fair sample of that noted fertilizer. The specimens for analysis were taken from five different pits, and each was judged be an average of the whole digging.

(3.) is an average of the marl dug by the Squankum Marl Company. It is supplied of this quality along the entire line of the Raritan and Delaware Bay Railroad, and also at Port Monmouth, for shipping. This marl is dug from the green and ash layers of the upper marl bed. The ash marl is poorer and more clayey than the green marl. But the mixture of the two is a good fertilizer, as both experience and the analysis show.

(4.) is an analysis of an averaged sample taken from a pile of 100 tons of marl, sent by the Freehold and Squankum Marl Company, to New Brunswick. A sample carefully averaged by my assistant, Mr. Bogardus, at the pits of the company, yielded $4.\frac{58}{100}$ per cent. of phosphoric acid.

(5.) is from the pits of the Cream Ridge Marl Company. The analysis is from an average specimen taken at the pits by my assistant, Mr. E. H. Bogardus.

(6.) is from the pits of the Pemberton Marl Company. It was from a sample prepared by J. C. Gaskill, Superintendent, and was averaged by cutting a uniform slice from the top to the bottom of the bank of marl and carefully mixing the whole.

(7) is an analysis of marl from the pits of the Vincentown Marl Company. The sample I believe to be a fair average.

(8) is the analysis of marl dug at White Horse, on the line of the Camden and Atlantic Railroad. There is an abundant supply of this marl to be had; and it is the source from which it can be easiest sent to all of Atlantic county, and the country along the Camden and Atlantic Railroad.

(9) is the analysis of a carefully averaged sample of marl from the West Jersey Marl Company's pits at Barnsboro'. Several hundred tons of it are sent over the West Jersey Railroad every day, to supply the wants of farmers in all the country which is reached by that road and its branches. The growing demand for this marl is the best proof of its good quality. It is from the green layer of the middle marl bed.

(10) is an analysis of an average sample of marl from the pits of Dickinson Brothers, at Woodstown. This marl has an excellent reputation. From 10,000 to 15,000 tons are sold annually to the neighboring farmers, and hauled away in wagons.

VALUATION OF MARL.

The value of these marls may be calculated in the same way the

other fertilizers were. The phosphoric acid is combined mostly with lime, though a little of it is probably combined with oxide of iron. The phosphates of lime and iron are both in very fine powder, or else in soft grains, so that while they cannot be quite as soluble as super-phosphate, they are certainly much more soluble than any bone-dust. Judging from Stockhart's table of prices and qualities of fertilizers, I think the phosphoric acid in our marl should be rated between that in guano, which is ten cents a pound, and that in steamed bones, which is eight and a quarter cents, and, therefore, propose for it in our calculations, *nine cents, gold, as the price per pound.* The potash in the marls is combined with silicic acid, and the compound, silicate of potash, is not readily soluble in water. Johnson's price, four cents per pound, is for soluble potash, as it is found in carbonate of potash, (pearlash), sulphate of potash, muriate of potash, (chloride of potassium), or crude potash. The potash in the marls is, however, dissolved out slowly by the action of water containing carbonic acid, and so becomes available. Until there is some more decided reason for fixing a different price, I will set down its value at two cents a pound

The value of the several marls given in the above table would then be easily made. Considering the phosphoric acid and potash as the only parts of the marl worth transportation, their values range from $3.50 a ton to $8.60 a ton; and I believe that in comparison with the prices paid for concentrated manures, they are worth those prices to the farmer. The cost must be taken when they are upon the soil, and not, as might be thought, when in store. I am confirmed in my opinion of their value by the testimony of successful farmers, who have used them for twenty years or more, and who assure me that they can better afford to incur an expense of from $5 to $8 a ton than to farm without them, or to use any other purchased fertilizers; and also confirmed by my own observation in all parts of New Jersey where marl has been used. It gives lasting fertility to the soil, while all other fertilizers are exhausted and the soils worn out. I have yet too see the first field that has ever been well marled that is now poor. One instance was found where poor and sandy land was marled more than thirty years ago, and has ever since been tilled without manure, and not well managed, which is still in good condition.

Occasionally marled fields are seen that do not grow crops as large as they once did, but all their fertility is immediately restored by a dressing of lime, an effect which could not have been produced by the lime on unmarled land.

I am averse to having the valuation on the various green-sand marls which are used in the State, based on the phosphoric acid and potash only in the above table of analyses, for I do not think they are the only useful substances in it. The fine carbonate of lime in number one is certainly of too much value to be neglected. And the sulphate of lime (gypsum) in many of them, is enough to be very beneficial to crops. The valuation, however, seems to be demanded, and this is the best approximation I can make.

Table showing the estimated value of the Phosphoric Acid and Potash in the ten samples of Marl analyzed.

No.	Phosphoric Acid.			Potash.			Total Value per ton.
	Per cent.	Per Ton. Pounds.	Value.	Per cent.	Per Ton. Pounds.	Value.	
1...	1.14	22.8	$2 05	3.65	73.0	$1 46	$3 51
2...	3.58	71.6	6 44	3.75	75.0	1 50	7 94
3...	2.59	51.6	4 64	4.25	85.0	1 70	6 34
4...	3.87	77.4	6 96	4.11	82.2	1 64	8 60
5...	1.33	26.6	2 39	5.67	113.4	2 27	4 66
6...	1.02	20.4	1 83	6.32	126.4	2 53	4 36
7...	2.33	46.6	4 19	3.53	70.6	1 41	5 60
8...	2.24	44.8	4 03	5.18	103.6	2 07	6 10
9...	2.69	53.8	4 84	6.31	126.2	2 52	7 36
10...	2.56	51.2	4 60	4.62	92.4	1 85	6 45

Of *potash*, one of the substances essential to vegetable growth, it may be said that its supply can be kept up easier, than can that of phosphoric acid. It is drawn from the soil principally to supply the mineral matter in straw, corn-stalks, potato tops, &c., and the restoration of these to the soil in barn yard manures, helps very largely in keeping up the supply, and is undoubtedly the cheapest way in which it can be done. Wood ashes contain potash in considerable quantity, and are always found to be worth more than they cost. The supply is limited, but they can be found in market, and some of the dealers in fertilizers are now bringing them in from Canada. Salts of potash it is said are now becoming an article of import from Germany, where they are obtained from mineral deposits over some of the salt mines.

The marl analyses on page 39 show that they contain a considerable per centage of potash; and it has been a popular notion that the fertilizing power of marl was due to the presence of that agent. Marl has a remarkable effect on the quality of potatoes, and they draw largely on the potash of the soil. Carbonate of potash in considerable quantity is found in the water from the Artesian well at Winslow; and that is supplied from the marl bed 343 feet beneath the surface. Pressure and carbonic acid here suffice to separate the potash from its combination with silica in the marl; and there can be no doubt that rain-water and the organic matter in the soil act upon marl in the same way to liberate the potash. It is found in practice that composts of marl and fermenting manures, or marl and guano, act much more quickly and efficiently than an equal value of any of these substances alone,

and this effect is probably due to the larger quantity of potash set free from the marl.

Of lime another one of the essential constituents of plant-food, it is enough to say that it is abundant, and the sources from which it can be obtained are well known. It can be bought as stone-lime, slacked lime, shell-lime, gas-lime, &c. Cost will determine which of these shall be used, for any of them will answer to supply the requisite amount of this substance. Much of the stone-lime that is sold contains a large per centage of magnesia; shell-lime is nearly pure-lime. The use of these is well understood. Gas-lime is slaked lime that has been used in purifying gas. It is coming into use, and the large quantity made in our great cities, together with the low price at which it is sold, makes it an object of interest to farmers.

The following are analyses of gas lime:

(1) Is Oyster Shell Lime fresh from the gas purifiers.

(2) " " " that has been exposed to the weather for two years after it was taken from the purifiers.

(3) Is Magnesian Lime fresh from the gas purifiers.

(4) " " that has been exposed to the weather for a year or more after it was taken from the purifiers.

Analyses.

	(1)	(2)	(3)	(4)
Lime,	44.24	48.49	32.39	31.16
Magnesia,	.72	.61	19.40	23.20
Potash and Soda,	.90	.55	.80	trace
Carbonic Acid,	33.60	32.90	11.05	22.45
Hypo-Sulphurous Acid,	.85	5.83	3.04	0.67
Sulphurous Acid,	.09	0.00	3.22	1.60
Sulphur (combined as sulphide),	.05	0.00	0.00	0.00
Oxide of Iron, Alumina and Phosphoric Acid,	1.65	2 20	6.17	3.73
Insoluble Matter (sand)	6.40	2.90	1.61	0.90
Volatile Matter,	5.95	4.42	15.02	8.62
Ammonia,		.28	3.27	6.20
Cyanides,	0.00	0.00	0.00	0.00
Sulpho-cyanides,	trace	trace	trace	0.00
Water,	4.80	1.50	3.50	1.00
	99.25	99.68	99.47	99.53

The analysis would seem to show that the principal fertilizing ingredient in the gas lime is fine carbonate of lime. This is always a valuable manure. The use of the other substances is not yet determined by any conclusive experiments; and it is not easy to settle it by any laboratory experiment, for the sulphites and hypo-sulphites undergo very remarkable changes when brought in contact with acids,

or other chemical substances. Its usefulness has been proved by the experience of many of the best farmers in the middle and southern counties of the State, who have used it as a substitute for common slaked lime and think it worth as much per bushel. It should be remarked, however, that the testimony in regard to the good effects of gas lime made from the magnesian lime is not so uniformly favorable as is that from the oyster shell lime. I have been informed that shell lime is used exclusively at the gas works in New York and Philadelphia, and is always preferred when it can be got at the same price with the magnesian lime.

It has been a question among fruit growers whether gas lime was not beneficial in destroying insects injurious to fruit. Near Flemington, Mr. Charles Bartles called my attention to his apple orchard, which last year had been manured with gas-lime. The orchard contained eleven acres. The trees were set out fifteen years ago, and had never borne but one crop, which was some years since. It had not been plowed in several years, but had been once dressed with wood ashes, and has been pastured by sheep. In the fall of 1868 he had it top-dressed with gas-lime, at the rate of fifty bushels an acre on part, and thirty bushels an acre on the rest. The lime was put on cross-wise of the rows of apple trees; this year the trees were loaded with apples, and the fruit was as smooth and fair as any brought from the West. It was remarkable, that where fifty bushels an acre was spread the leaves were greener, the annual growth of wood greater and the crop of fruit larger than where only thirty bushels were put on. One experiment, of course, is not conclusive, but this is certainly a very suggestive one.

Nitrate of potash, or other material containing nitrogenous matter, is the last of the substances mentioned as essential to the growth of plants. The other forms of nitrogenous matter are nitrate of soda and ammonia, or its elements. Nitrate of potash, or saltpetre, though an excellent fertilizer, is quite out of the question, on account of its high price. Nitrate of soda has been in market at reasonable prices, but was never extensively used in our country, and at present cannot be found. Our principal resource then is ammoniacal manures, and of these the great supply must be obtained from the barn yard, and from the droppings of animals. Too much importance cannot be attached to this mode of obtaining manure, and that farmer will always be most successful who secures the largest amount of this fertilizer. But after all the ingenuity possible has been exercised, this source of supply will not satisfy the demands of an improved agriculture. Peruvian guano furnishes a rich fertilizer, and its ammonia always does its work and gives satisfaction to its consumers, but it is high-priced and transient in its effects; it contains fifteen per cent ammonia, ten per cent. phosporic acid, and five per cent. potash. Fish guano, made from the shoals of fish which come to our shores, is another source of ammonia. It can be made at various places along our

coast. It contains about nine per cent. of ammonia and nearly eight per cent. of phosphoric acid, and its price varies from $20 to $35 a ton.

Cancerine, a fertilizer made from the shells of the king-crab, by simple drying and grinding, is also rich in the elements of ammonia. It contains 10.5 per cent. of ammonia and 2¾ per cent. of phosphoric acid, and is sold for $30 a ton.

Ammonia is also found in various other fertilizers, in moderate or small quantities, and it can be obtained in a very concentrated form in sulphate of ammonia, which contains from 22 to 24 per cent. ammonia, and sells for 7 or 8 cents a pound.

Peat or muck, the vegetable matter in swamps and bogs, may be profitably used as a source of ammonia. It is a vegetable matter that has undergone a partial decay, and has ceased to undergo any further change. By causing it to decompose or decay, it yields ammonia. I have here a specimen of pulverized dry peat. I mix it with slaked lime and then just moisten it with water. Now when I hold over it a glass rod moistened with hydrochloric acid, a white smoke is at once formed, by the ammoniacal gas which is rising from the peat, combining with the vapor of the acid to form solid hydrochlorate of ammonia, and so make the gas from the decomposing peat visible. The average amount of ammonia in thirty-three samples of air dried peat, was given by Professor S. W. Johnson, in his Essay on Manures, as 1.37 per cent, which is considerably more than is found in good stable manure. All that is needed to make peat available as a source of manure, is to get it in the process of decay, by exposing it to the air for a long time, or else to compost it with lime or barn yard manure. The best cabbage I have seen this year, and I have never seen any better, was raised in Ocean county, on poor land, by the use of peat and lime only. I should remark too, that trial shows ammonia to be present in the vegetable matter from salt marshes; and some Cape May farmers report that excellent crops have been raised by them, from the use of salt-meadow peat.

But by far the best means of supplying ammonia to crops, when a little time can be allowed, is to raise clover. This is the experience of thrifty farmers everywhere. There is an exceedingly interesting account of the action of clover upon soils and crops, in a lecture delivered before the Royal Agricultural Society of England, by Dr. Voelcker, Chemist to the Society. He says that in a clover crop we remove from the soil fully three times as much mineral matter, and fully six times as much ammonia as we do in a wheat crop. And that "the roots contain quite as much of these substances as the stems and leaves. Clover, by its long roots, penetrates a large mass of soil. It gathers up, so to speak, the phosphoric acid and the potash, which are disseminated throughout a large portion of the soil, and when the land is ploughed the roots are left in the surface, and in decaying they leave in an available condition, the mineral sub-

stances" which the succeding crops require. The "accumulation of nitrogen in the soil after the growth of clover, is extremely large. Even when the clover crop is insignificant, a large quantity of nitrogen, amounting to tons in each acre is accumulated in the surface soil, and the better the clover crop, the greater is the accumulation of nitrogen." "On clover soil once mown and left for seed, I found a larger per centage of nitrogen than where the clover was mown twice. The total quantity of nitrogen calculated per acre for twelve inches of soil amounted on that portion of the field mown twice for clover, to 5249½ pounds, whereas the total amount of nitrogen in twelve inches of soil on that portion of the field which was mown only once and then left to stand for seed was 8126½ pounds." There is no other mode of obtaining ammonia that can compare with this for cheapness or amount.

In thus presenting to you some particulars of the elements of plant food, and the sources from which they can be derived, I do not desire to give to this portion of the wide subject of farming an undue importance. I know full well that the first essential to success in agriculture, is to be master of the operations of farm work; to know when and how to plow, to plant and to hoe; to be familiar with the care and management of stock, and to know the thousand little but essential things which experience alone can teach. And I always feel, when in the presence of experienced farmers, that I am in danger of speaking to them of things which they know far better than I do. It is only after these essentials of your art are mastered, that I would add something further. Now, that the exhausting system of tillage is past, and successful farming cannot be carried on without restoring to the soil the elements which have been taken away in the crops; it has become of the highest importance to know how to supply these elements in the cheapest way. There is no farmer among us at the present day who can afford to hold his farm, unless he makes plans and expends money to keep up its fertility. And to do this he must inform himself in regard to the cost and quality of the various fertilizers he has to use. If he buys prepared manures, and is not competent to judge of their quality, he may depend upon it that dealers will be found who are ready to take advantage of his ignorance. With a more general diffusion of scientific knowledge among farmers, the enormous frauds that are now perpetrated in the manufacture and sale of worthless manures would be impossible. The farmers of Great Britain and of France have advanced farther in this direction than we have. If super-phosphates are sold there, they are rated according to the per centage of soluble and insoluble phosphoric acid they contain, and the strength is guaranteed. So too of manures containing ammonia or potash, the per centage of these substances is given, and the purchaser buys understandingly. The dealers are not more honest, but a longer experience has taught the farmer to know his own wants better. Our farmers can reach this by a more

thorough education in the sciences relating to their pursuit. To the skill and industry they now have they must add all the information they can acquire by reading, and by comparison of views with others.

Farmers' clubs are important means for advancing knowledge among those who are desirous of improvement. Wherever in our state, they are in active operation, there good farming is sure to be seen, and prosperous farmers to be found. If it were not invidious I could mention some cases where such associations can be seen, and the thrift, the profit and the pride of profession which attends combined effort can be fairly shown. I trust the day is not far distant when many such clubs will be organized in every county of the state. If taken hold of by those who are conscious there is much yet to learn, and are determined to make greater attainments in their art, such associations are sure to succeed.

It is important also to train now those who are soon to take the places of those now in active life. With the fascinations of city life, and the attractions of mercantile, manufacturing or mechanical pursuits in view the young are apt to dislike the slower operations of husbandry, and to aspire after other fields of labor than those of the farm. This is not a correct view, greater foresight, more careful and persevering attention, and longer preparation are needed for the highest success in farming than in any other art. The greatest attainments can be used in this calling. Be careful then to educate your sons thoroughly. Let them have as liberal an education as possible. Train them for all the duties of a citizen, as fully as if they were to be ministers or lawyers, or doctors. They will then see that Agriculture is worthy their pursuit, and their own characters will add to its dignity.

3 0112 105948639